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(71) Applicants:
- **FORD MOTOR COMPANY LIMITED**
  Brentwood, Essex CM13 3BW (GB)
  Designated Contracting States:
  GB
- **FORD-WERKE AKTIENGESELLSCHAFT**
  50735 Köln (DE)
  Designated Contracting States:
  DE
- **FORD FRANCE S. A.**
  92506 Rueil-Malmaison Cédex (FR)
  Designated Contracting States:
  FR

(72) Inventors:
- **Smith, Graeme Peter**
  Bishops Stortford, Herts, CM23 4BW (GB)
- **Clouston, Eric Nicol**
  Chesterton, Cambirdge, CB4 1NW (GB)

(74) Representative: **Messulam, Alec Moses et al**
A. Messulam & Co.
24 Broadway
Leigh-on-Sea Essex SS9 1BN (GB)

(54) Antenna cluster for a motor road vehicle collision warning system

(57) A motor road vehicle collision warning system (1) comprises an obstacle sensing system (3), comprising a plurality of sensors (5) together capable of sensing obstacles around the vehicle (7) and generating obstacle of concern signals when obstacles are sensed, and a warning control system (9) for receiving said obstacle of concern signals and for determining whether a collision warning signal should be generated, in which the sensing system includes at least one antenna cluster (11) mounted in the region of a corner (13) of the vehicle (7), the antenna cluster (11) comprising a radar transmit antenna (15) and two receive antennas (17,19) the transmit antenna (15) mounted between the receive antennas (17,19) a first receive antenna (17) facing towards the front of the vehicle and a second receive antenna (19) facing towards the rear of the vehicle, and means (21) to trigger the operation of the transmit antenna (15) and one or both of the receive antennas (17.19).

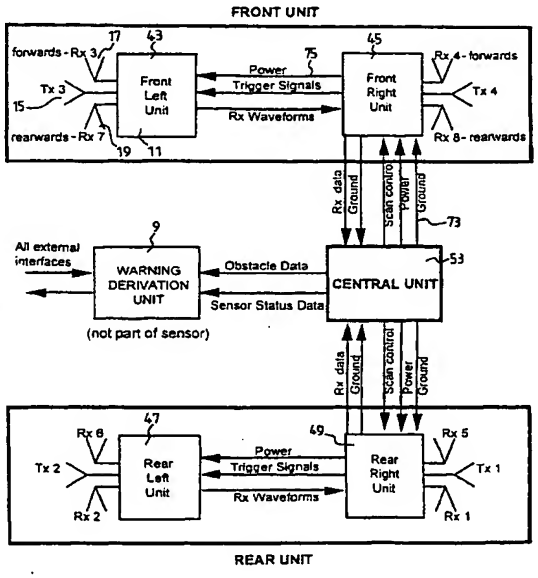

FIG.2

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Description

[0001] This invention relates to collision warning systems for motor land vehicles and in particular to an antenna cluster for use in such a collision warning system.

[0002] Various different types of collision warning systems have been proposed for motor vehicles which will warn of potential collision with moving targets, primarily other vehicles and stationary obstacles especially when parking. Such systems include 'closing vehicle same lane warning systems' for looking behind a vehicle when it is travelling forwards for noting when a vehicle is approaching from the rear, parking aids for looking forwards when the vehicle is travelling slowly forwards and backwards when the vehicle is travelling slowly backwards, backup aids, short range frontal collision warning systems for looking ahead of the vehicle while driving forwards, parking space measuring aids for measuring the length of a parallel parking space to the side of the vehicle, driver induced impaired visibility aids to help ensure that the driver can notice vehicles approaching his side in an overtaking lane, side vision aids for looking to the side of the vehicle and lane change aids for checking that the driver is free to overtake, or indeed move to an inside lane.

[0003] Typically these have all been designed as discrete packages and so a vehicle having a multiplicity of these aids includes a plurality of sensors of different types and ranges looking around the vehicle.

[0004] There are many different types of sensor available including radar and ultrasound which are chosen dependant upon the range required for the sensor.

[0005] The majority of sensor types transmit a signal which is reflected from an obstacle and then received. Measurement of the time delay between transmission and receipt of the signal allows the position of the obstacle to be calculated.

[0006] The common features of any of the collision warning systems set out are that they include a sensing system, which has at least one sensor which has a field of view in which it may detect an obstacle and a warning control system which receives obstacle of concern signals from the sensor and analyses them to determine whether a collision warning signal should be generated. However for each application and at any one time only obstacles in a particular area, known as the zone of concern, are of particular interest. For example in the parking aid, as the vehicle moves forward the area to the front and sides of the vehicle is the zone of concern. During reversing the rear of the vehicle is of primary concern.

[0007] A collision warning system for a motor vehicle which is capable of acting as a multifunctional system is described in the applicants previous PCT application PCT/GB97/01728 in which each of the plurality of sensors has a predetermined field of view in which it is capable of detecting obstacles and an instantaneous field of view within which obstacles sensed by the sensor causes the obstacle sensing system to generate an obstacle signal, a vehicle operation sensing means for detecting at least one property of the vehicles operation, a zone of concern control means for defining a zone of concern within which sensed obstacles trigger the generation of an obstacle of concern signal whereby the zone of concern is defined in dependence on the property or properties of the vehicles operation sensed by the vehicle operation sensing means, and for controlling the sensors such that the instantaneous field of view of the sensors together cover the zone of concern.

[0008] The system includes four sensors which each comprise a transmitter antenna and a receiver antenna. The present invention relates to an antenna cluster especially suitable for use in such a system.

[0009] A motor road vehicle collision warning system comprising an obstacle sensing system, comprising a plurality of sensors together capable of sensing obstacles around the vehicle and generating obstacle of concern signals when obstacles are sensed, and a warning control system for receiving said obstacle of concern signals and for determining whether a collision warning signal should be generated, in which the sensing system includes at least one antenna cluster mounted in the region of the corner of the vehicle, the antenna cluster comprising a radar transmit antenna and two receive antennas, the transmit antenna mounted between the receive antennas, a first receive antenna facing towards the front of the vehicle and a second receive antenna facing towards the rear of the vehicle, and means to trigger the operation of the transmit antenna and one or both of the receive antennas.

[0010] Preferably the antennas transmit and receive impulse radar signals since these provide a wide coverage. A single impulse radar sensor enables a wide field of view (up to 270°when mounted on the corner of a vehicle) but with no angular discrimination facility.

[0011] Preferably the sensing system operates by interpolating the data from two or more receive antennas to locate the target in two dimensions and therefore pinpoint its position accurately. Preferably therefore the system includes a plurality of antenna clusters including a transmit and two receive antennas.

[0012] It has been found that efficient coverage of the area about the vehicle may be achieved by the use of 4 antenna clusters, one at each corner of the vehicle.

[0013] Preferably the system includes a scanning timer which operates the antenna transmit and receive antennas in a timed scheduled order.

[0014] Preferably each scan comprises transmitting a signal from one transmit antenna and receiving the signal from

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three receive antennas.

[0015] Typically each scan will last in the region of 25mS The warning system is preferably of the type described in the applicants previous PCT application no PCT/GB97/01728 in which each of the plurality of sensors has a predetermined field of view in which it is capable of detecting obstacles and an instantaneous field of view within which obstacles sensed by the sensor causes the obstacle sensing system to generate an obstacle signal, a vehicle operation sensing means for detecting at least one property of the vehicles operation, a zone of concern control means for defining a zone of concern within which sensed obstacles trigger the generation of an obstacle of concern signal whereby the zone of concern is defined in dependence on the property or properties of the vehicles operation sensed by the vehicle operation sensing means, and for controlling the sensors such that the instantaneous field of view of the sensors together cover the zone of concern.

In this case the selection of the transmit and receive antenna combination to be operated at any one time is dependant upon the zone of concern. Thus instead of scanning through all possible combinations of the antennas to receive an all around view of the vehicle, only a selected region of the vehicle is viewed.

[0016] Alternatively the scanning around the vehicle may continue, but the control system of the sensors may only act upon obstacles found in the zone of concern.

[0017] A motor road vehicle collision warning system in accordance with the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a block diagram of the key components in the system;
Figure 2 is a block diagram of the antenna clusters of the system;
Figure 3 is a diagram illustrating the zone of concern for specific modes of operation of the system;
Figure 4 is a schematic plan of a vehicle illustrating the antenna cluster position;
Figure 5 is a diagram illustrating the instantaneous field of view of one sensor;
Figure 6 is a view of the whole field of view of the sensing system;
Figure 7 is a schematic view illustrating calculation of an obstacles position;
Figure 8 is a block diagram of the radar system;
Figure 9 is a block diagram of the front right antenna; and,
Figure 10 is a block diagram of the front left antenna cluster.

[0018] A motor road vehicle collision warning system 1 comprises an obstacle sensing system 3, comprising a plurality of sensors 5 together capable of sensing obstacles around the vehicle 7 and generating obstacle of concern signals when obstacles are sensed, and a warning control system 9 for receiving said obstacle of concern signals and for determining whether a collision warning signal should be generated, in which the sensing system includes at least one antenna cluster 11 mounted in the region of a corner 13 of the vehicle 7, the antenna cluster 11 comprising a radar transmit antenna 15 and two receive antennas 17, 19, the transmit antenna 15 mounted between the receive antennas 17, 19, a first receive antenna 17 facing towards the front of the vehicle and a second receive antenna 19 facing towards the rear of the vehicle, and means 21 to trigger the operation of the transmit antenna 15 and one or both of the receive antennas 17, 19.

[0019] The collision warning system is as described in PCT application PCT/GB97/01728 in which each of said plurality of sensors 5 has a predetermined field of view in which it is capable of detecting obstacles and an instantaneous field of view within which obstacles sensed by the sensor causes the obstacle sensing system 3 to generate an obstacle signal and the collision warning system also includes a vehicle operation sensing means 23 for detecting at least one property of the vehicles operation, a zone of concern control means 25 for defining a zone of concern within which sensed obstacles trigger the generation of an obstacle of concern signal whereby the zone of concern is defined in dependence on the property or properties of the vehicles operation sensed by the vehicle operation sensing means 23, and for controlling the sensors such that the instantaneous field of view of the sensors 5 together cover the zone of concern.

[0020] Figure 3 illustrates the zones of concern about the vehicle in which, in particular modes, the presence of an obstacle should generate a warning signal. Throughout these zones of concern the preferred elevation coverage will be from about 0.15m up to the height of the vehicle. Clearly objects above this height such as bridges may be ignored.

[0021] The zone of concern 27 for the closing vehicle same lane system covers the lane width within which the vehicle travels , usually 3.7m and extends 30m to the rear of the vehicle. The zone of concern 29 for the parking aid is in two areas 31 and 33 to the front and rear of the vehicle respectively. The area 31 to the front of the vehicle extends 0.6m to the front of the vehicle and 0.5m to each side and the rear area 33 extends 1.5m to the rear for a car, but would be 3m for a van and 0.5m to each side of the vehicle.

[0022] The zone of concern 35 for a backup aid extends 10m to the rear and is wider than the vehicle allowing for turning of the vehicle.

[0023] The side vision aids zone of concern 37 extends from the wing mirror (not shown) of the vehicle to the rear

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by 12m and a lane width to each side.

[0024] The zone of concern 39 for the Driver Impaired Visibility Aid is to the side only of the vehicle and a subpart of the zone of concern 37 of the side vision aid.

[0025] The zone of concern 41 for the frontal collision warning extends 10m to the front of the vehicle and extends wider than the vehicle to allow for turning of the vehicle.

[0026] The layout of the antenna clusters 11 is illustrated in figure 4 which illustrates four clusters 43, 45, 47 and 49 each mounted inside the bumpers 51 of the vehicle. Each is part of the sensing system 3. Each antenna cluster comprises a transmit antenna (Tx1, Tx2, Tx3 and Tx4) and two receive antennas (Rx1 to Rx8). The front left unit 43 comprises transmit antenna Tx3 mounted between front facing receive antenna Rx3 and rear facing receive antenna Rx7. The front right unit 45 comprises transmit antenna Tx4 mounted between front facing receive antenna Rx4 and rear facing receive antenna Rx8. The rear left unit 47 comprises transmit antenna Tx2 mounted between front facing receive antenna Rx6 and rear facing receive antenna Rx2. The rear right unit 49 comprises transmit antenna Tx1 mounted between front facing receive antenna Rx5 and rear facing receive antenna Rx1. A central unit 53 includes a power supply for the sensors and houses the means 21 to trigger the operation of the sensors of the antenna clusters.

[0027] Figure 5 illustrates the instantaneous field of view of transmit antenna Tx3 when its signal is received by receive antenna Rx4. If figure 6 is referred to, it can be seen that by use of different transmit/receive combinations a series of overlapped areas are created within which at least two antenna pairs can detect the obstacle.

[0028] As can be seen in figure 7 if the range from one sensor R1 is known ,and the range from second sensor R2 is also known, together with the distance between the two sensors D, this can be used to plot the co-ordinates X and Y of the obstacle.

[0029] The system is a multifunctional system capable of operating in all the modes set out and shown in figure 2. As can be seen in figure 6, the field of view of all the sensors allows all the zones of concern to be covered.

[0030] The system also includes mode switch 55 which is coupled to driver select control 57 allowing the selection of a mode of operation, for example if the driver is about to park. It is also coupled to mode control means 59 which receives signals from the vehicle operation sensing means 23 to determine the type of sensing mode required.

[0031] For example selection of reverse gear would trigger reversing aid, a forward gear and the selection of the indicator would trigger the side vision aid. Driving at speeds of over 5 m.p.h in a forwards direction would trigger the Closing Vehicle Same Lane Aid and the Frontal Collision Warning Aid. These operate at the same time. Whilst these are in operation, a display (not shown) indicates to the driver which aid is in operation.

[0032] The parking aid is triggered only by selection by the driver by the driver select control 57.

[0033] The sensors are impulse radar sensors and each transmit antenna Tx transmits a series of pulses. The transmitted signal is in the form of a short radio frequency pulse, typically of 0.1to 5 nanoseconds duration depending on the rise time and the frequency response characteristics of the antenna.

[0034] The pulses are similar to those generated by the system shown in published application WO 90/13048. The transmission of pulses by an antenna is initiated by a timing generator 61 which triggers a transmit generator 63 of a transmitter 65 connected to the transmit antenna Tx.

[0035] The timing generator is also connected to two gating devices 67 and 69 which are, in turn, both connected to a receive antenna Rx. Each of the gating devices, in response to a signal from the timing generator 61 samples the signals received by the antenna Rx.

[0036] The outputs from the gating devices are connected to a signal and control processor 71 which analyses the signal to determine whether or not to initiate an alarm or control interface.

[0037] The processor 71 is also connected to a motion sensor (not shown) which measures the speed with which the car is moving, and to the vehicle control system.

[0038] In use, the timing generator 61 causes a selected one of the gating devices to sample the output of the receive antenna Rx at a predetermined delay (normally of 1 to 200 nanoseconds corresponding to 15cm to 30m) after transmission of a given pulse by the antenna Tx. If the antenna Rx receives the reflection of the pulse during a given sampling period, this is indicative of the transmit pulse having travelled from the transmit antenna Tx to a reflecting surface and back to the receive antenna Rx in the delay between the transmission of the pulse and and sampling period.

[0039] In this case the timing generator triggers the gating device of more three receive antennas Rx so that signals received by more than one antenna can be used to accurately pinpoint an obstacle as illustrated in figure 7.

[0040] The transmit and receive antennas are triggered in a repeated sequence of four scans, each 25ms long. Only one transmit antenna Tx is used in each scan, but three receive antennas are used at the same time, as shown in the table below.

Antenna	Front/ Rear	Left/ Right	Forwd/ Rearwd	Scan 1	Scan 2	Scan 3	Scan 4
Tx1	Rear	Right	Both	X			
Tx2	Rear	Left	Both			X	

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(continued)

Antenna	Front/ Rear	Left/ Right	Forwd/ Rearwd	Scan 1	Scan 2	Scan 3	Scan 4
Tx3	Front	Left	Both		X		
Tx4	Front	Right	Both				X
Rx1	Rear	Right	Rearwd	X		X	
Rx2	Rear	Left	Rearwd	X		X	
Rx3	Front	Left	Forwd		X		X
Rx4	Front	Right	Forwd		X		X
Rx5	Rear	Right	Forwd	X			
Rx6	Rear	Left	Forwd			X	
Rx7	Front	Left	Rearwd		X		
Rx8	Front	Right	Rearwd				X

[0041] Each scan consists of a Transmit pulse being transmitted by a transmit antenna, for example Tx1, the timing generator generating a time delay and then sampling the signals received by three of the receive antennas, in this case, Rx1, Rx2 and Rx5.

[0042] The front unit is mounted in the front bumper (not shown) with a single external connector 73 on the right hand side , for connection to the central unit 53. It includes the front right unit 45 and the front left unit 43. The front right unit 45 is directly connected to a cluster of three antennas - a transmit antenna Tx4, a forward facing receive antenna Rx4 and a rearward facing receive antenna Rx8. The front left unit 43 is similarly connected to another three antennas, Tx3, Rx3 and Rx7.

[0043] The connector 73 is a single multiway connector which feeds power and a scan control signal to both the front units and outputs from the front units detected obstacle data as a digital data stream.

[0044] Connections 75 between the front right unit 45 and the front left unit 43 are within the bumper. Once assembled these connections are not accessible. The connection 75 is a screened multiway connection consisting of:

[0045] To unit 43: Power;ground;Tx3 Trigger; Rx7 and Rx3 trigger

[0046] From unit 43: Audio outputs from samplers.

[0047] The central unit 53 receives power from the vehicle 12V and generates regular power for both front and rear units at +5.0v and -5.0v. It receives power only when the ignition is in the run position.

[0048] The RF electronics within the units are connected to the antennas by connections within the bumper, which are radio frequency connections.

[0049] Each transmit antenna Tx is a dual beam antenna to front and rear with a band of operation of 5.46 to 7.25 GHz. Each receive antenna Rx receives signals in the same frequency range, but is a single beam to the front or rear at 15° relative to the centre line of the vehicle.

[0050] The scan control signal (front) is a 20 Hz square wave which selects the tranmitter Tx4 on the RHS and the transmitter Tx3 on the LHS on alternate scans - positive going edge initiates a scan on the lhs and the negative going edge initiates a scan on the rhs.

[0051] When the rhs transmitter Tx4 is used, the RHS rearward facing receiver Rx8 is selected and the LHS rearward facing receiver Rx7 is not. When the LHS transmitter Tx3 is used, the LHS rearward facing receiver Rx7 is selected and the RHS rearward facing receiver Rx8. The forward facing receivers Rx3 and Rx4 are both selected for either transmitter.

[0052] The sampler timing is set to give the following nominal scans:

Sampler	Min Range	Max Range	Scan length
1	(-2.344m)	2.344m	4.69m
2	2.344m	7.031m	4.69m
3	7.031m	11.719m	4.69m
4	11.719m	16.406m	4.69m

[0053] As can be seen in figures 9 and 10, connected to each Receive antenna Rx is a chain of four samplers. Only one chain will be described as an example. This is the chain connected to Rx4. The antenna is connected to a protection circuit 77 to cut off at a peak of less than 1V which is coupled to first sampler 79. Signals from the first sampler 79 are fed through an rf amplifier 81 with a gain of over 10.5mB to an array of three further samplers 83, 85 and 87.

[0054] The timebase 89(part of the timing generator) generates a Tx trigger signal and four Rx trigger signals for

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each side of the front unit. The scan control (front) signal initiates each scan. The Tx trigger signal is fed to pulse generator 91 which generates an impulse radar signal via filter 93 and protection circuit 95. The Rx trigger signals are generated at time delays corresponding to the scan lengths required for each sampler. This is typically at 31.25ns time intervals.

[0055] Signals from the scanners are fed via an analogue to digital converter 97 to detection means 99 which feeds data to central unit 53.

[0056] The rear unit is identical to the front unit but mounted in the rear bumper. Also the Scan control (rear) signal is offset by 25ms from the Scan control(front) signal.

Claims

1. A motor road vehicle collision warning system (1)comprising an obstacle sensing system(3), comprising a plurality of sensors (5) together capable of sensing obstacles around the vehicle (7)
   and generating obstacle of concern signals when obstacles are sensed, and a warning control system (9) for receiving said obstacle of concern signals and for determining whether a collision warning signal should be generated, in which the sensing system includes at least one antenna cluster (11) mounted in the region of the corner (13) of the vehicle(7), the antenna cluster (11) comprising a radar transmit antenna (15) and two receive antennas (17,19), the transmit antenna (15) mounted between the receive antennas (17,19), a first receive antenna facing towards the front of the vehicle and a second receive antenna (19) facing towards the rear of the vehicle (7), and means to trigger the operation of the transmit antenna (15)and one or both of the receive antennas(17,19).

2. A collision warning system according to claim 1, in which the system (1) includes a plurality of antenna clusters (11) including a transmit (15) and two receive antennas (17.19).

3. A collision warning system according to claim 2, in which the system (1) includes four antenna clusters (11), one at each corner of the vehicle(7).

4. A collision warning system according to claim 1 or 2 which includes a scanning timer which operates the transmit (15) and receive antennas (17,19) in a timed scheduled order.

5. A collision warning system according to claim 4, in which each scan comprises transmitting a signal from one transmit antenna (Tx) and receiving the signal from three receive antennas (Rx).

6. A collision warning system according to claim 5,in which each scan lasts substantially 25ms.

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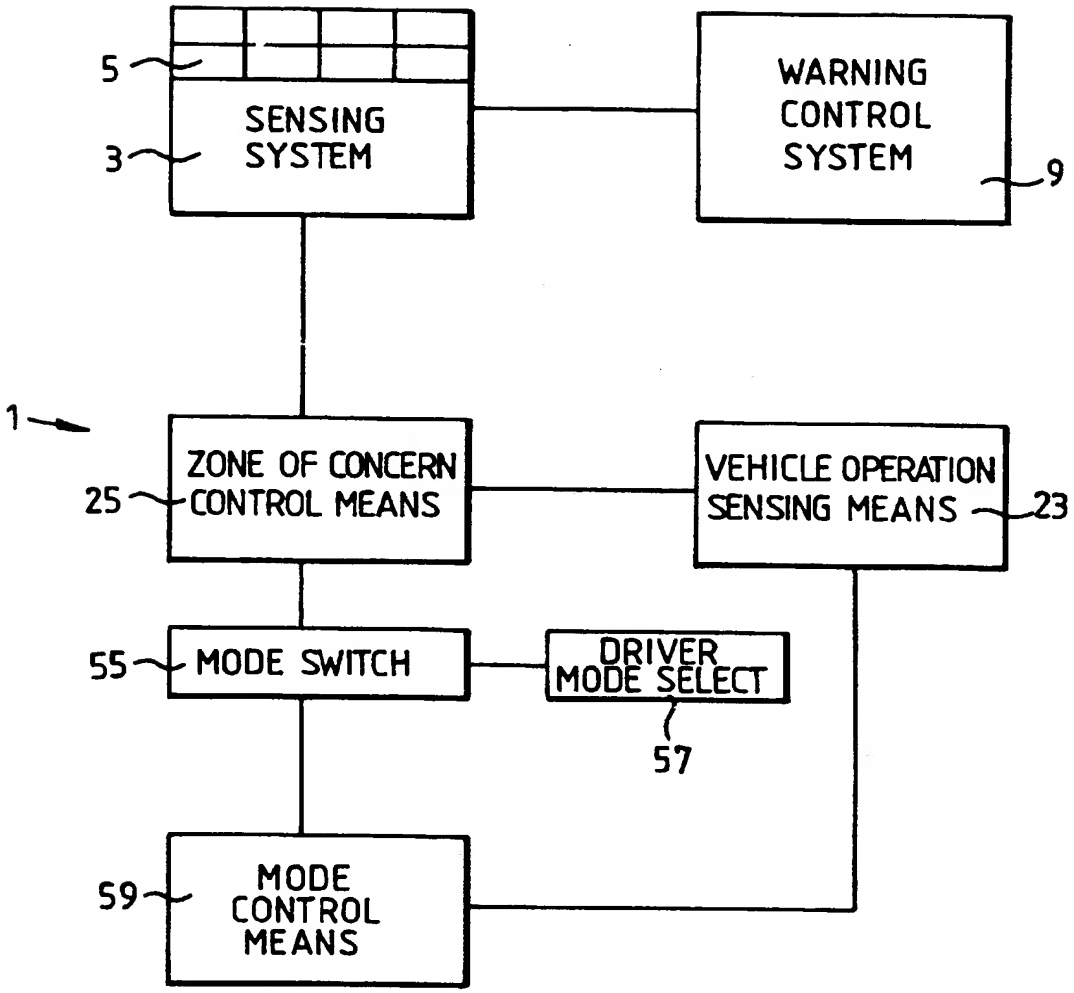

FIG.1

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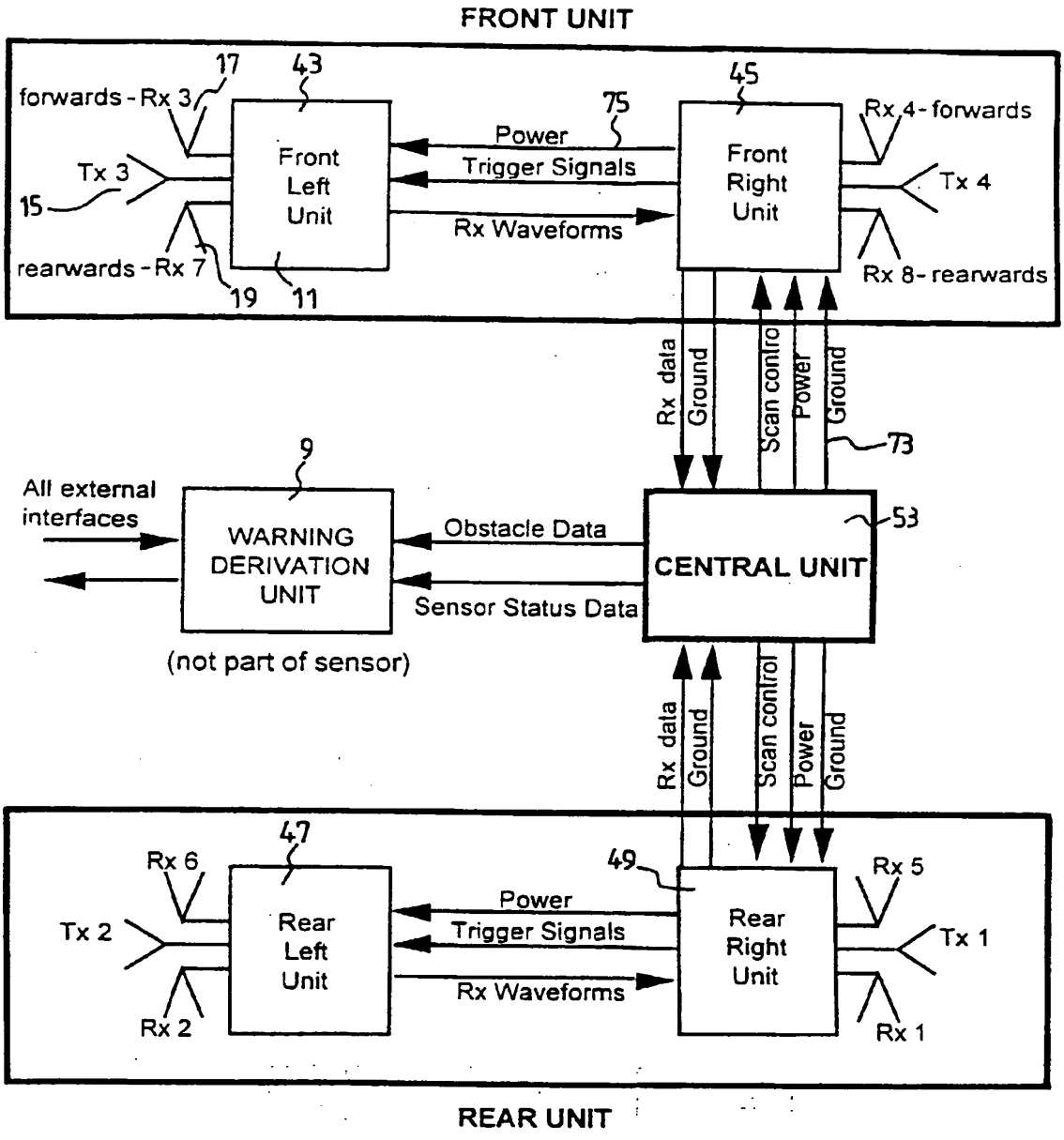

FIG.2

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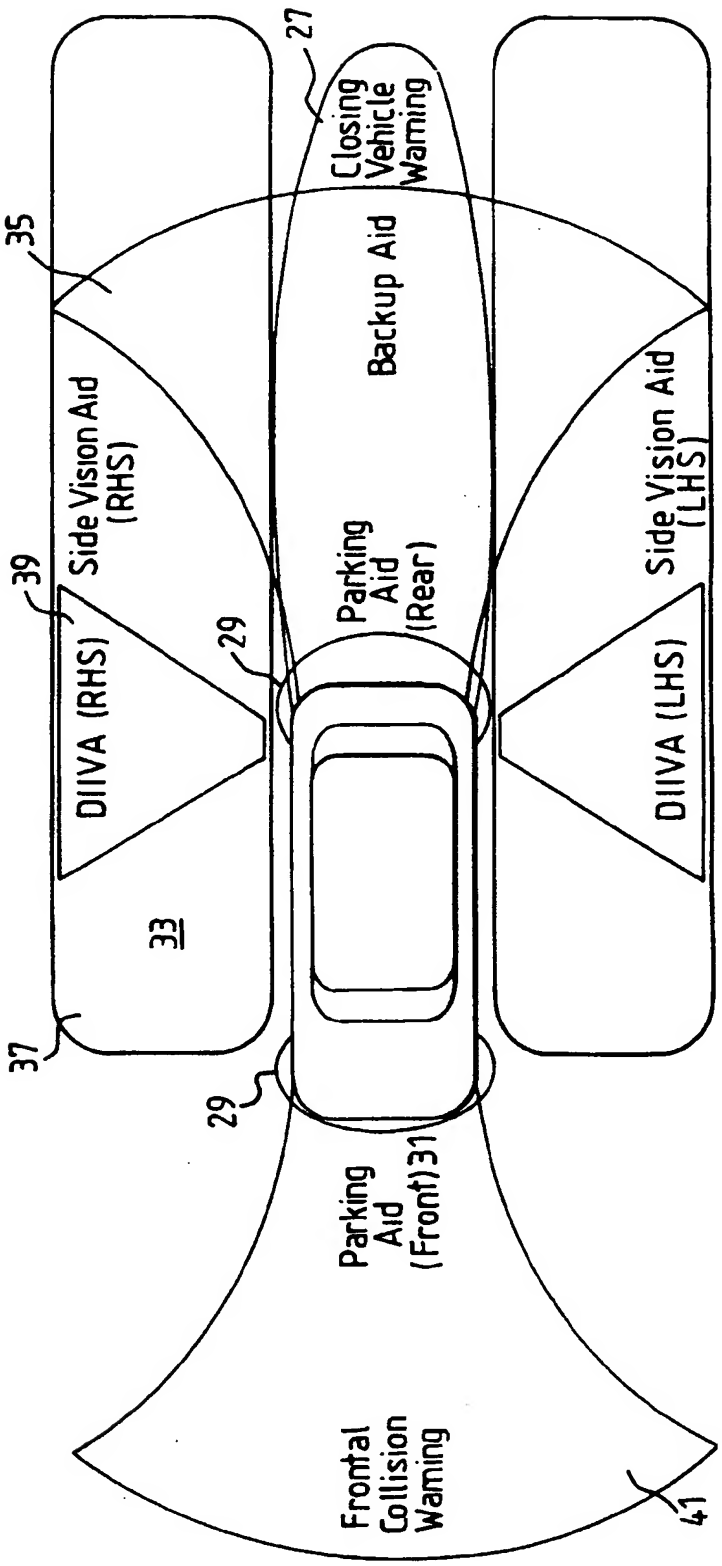

FIG.3

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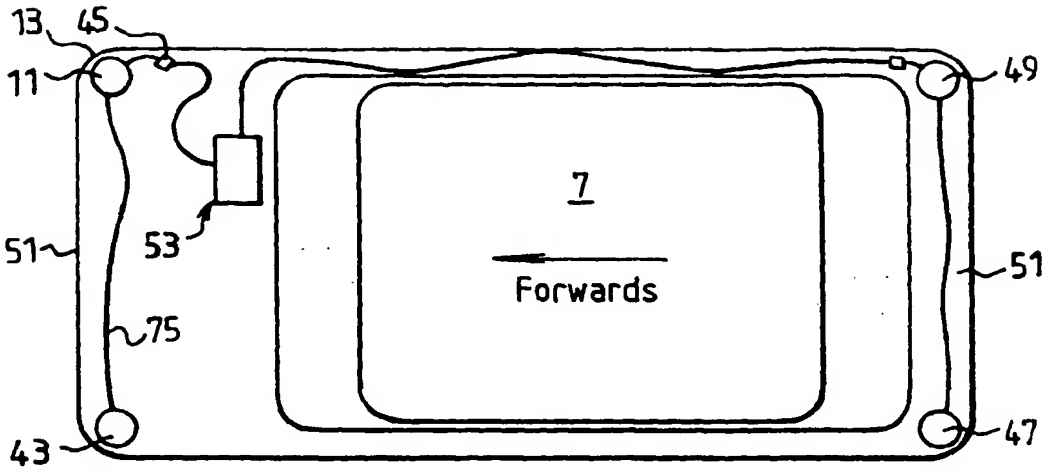

FIG.4

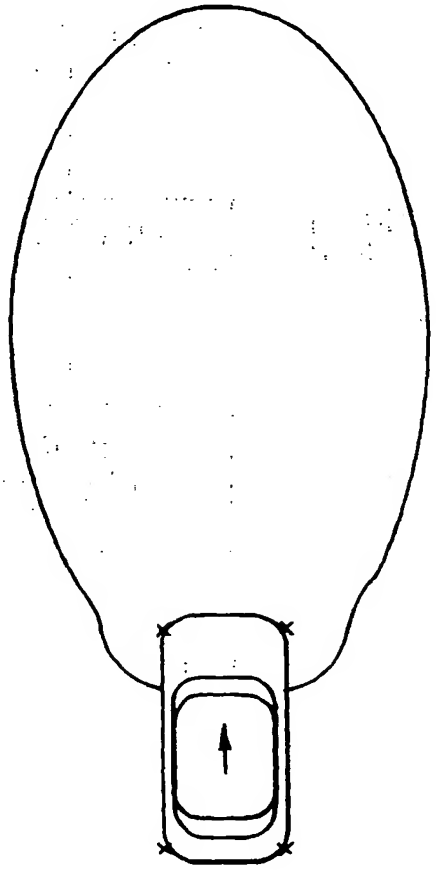

FIG.5

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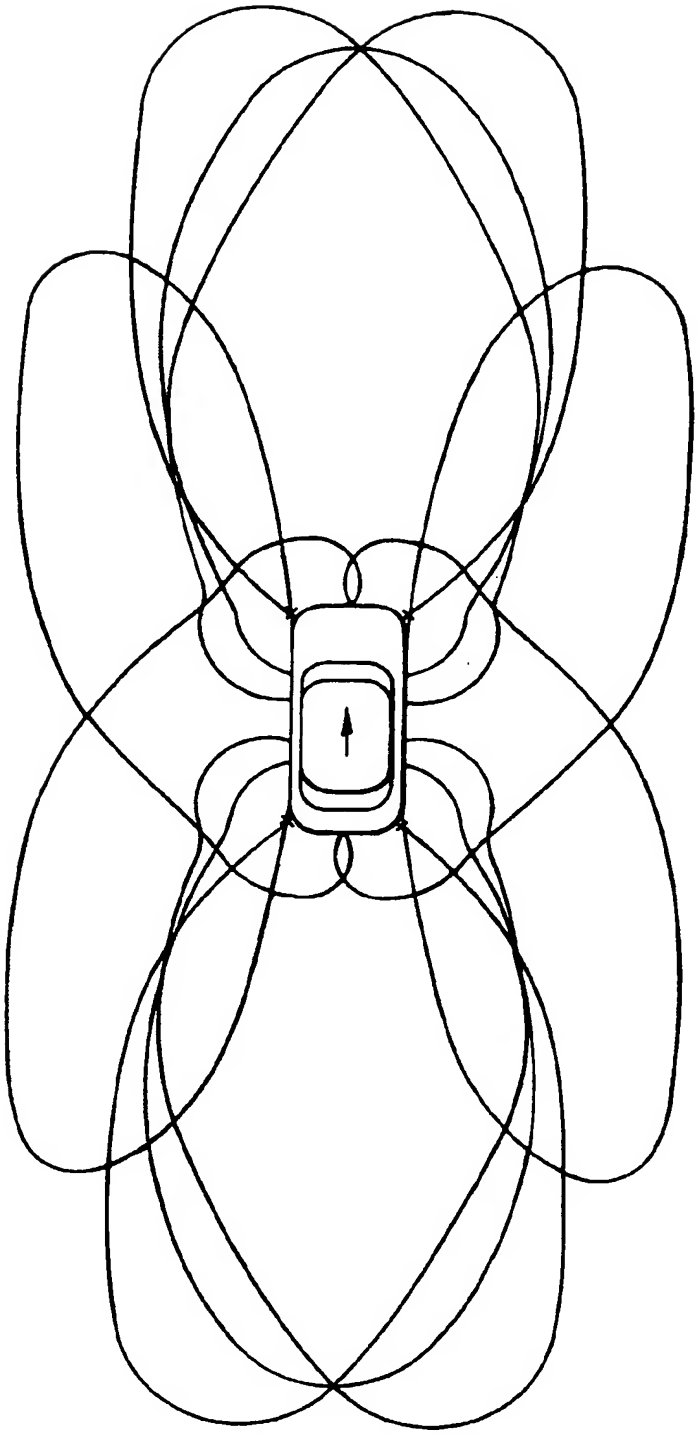

FIG.6

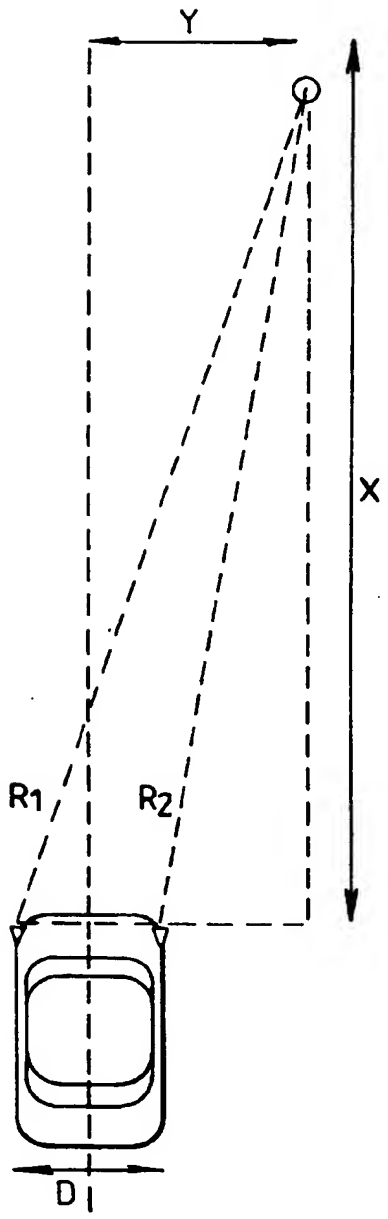

FIG.7

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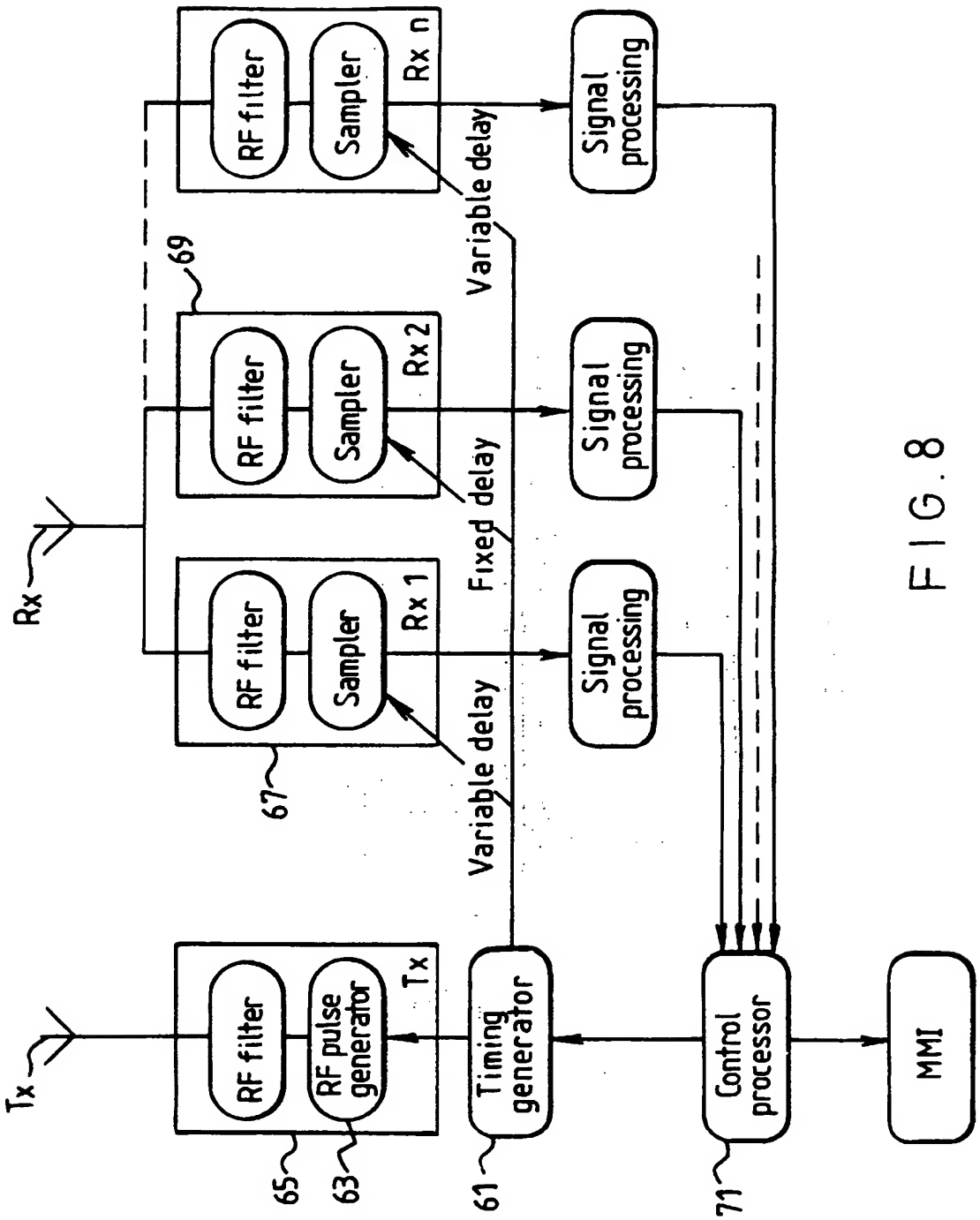

FIG. 8

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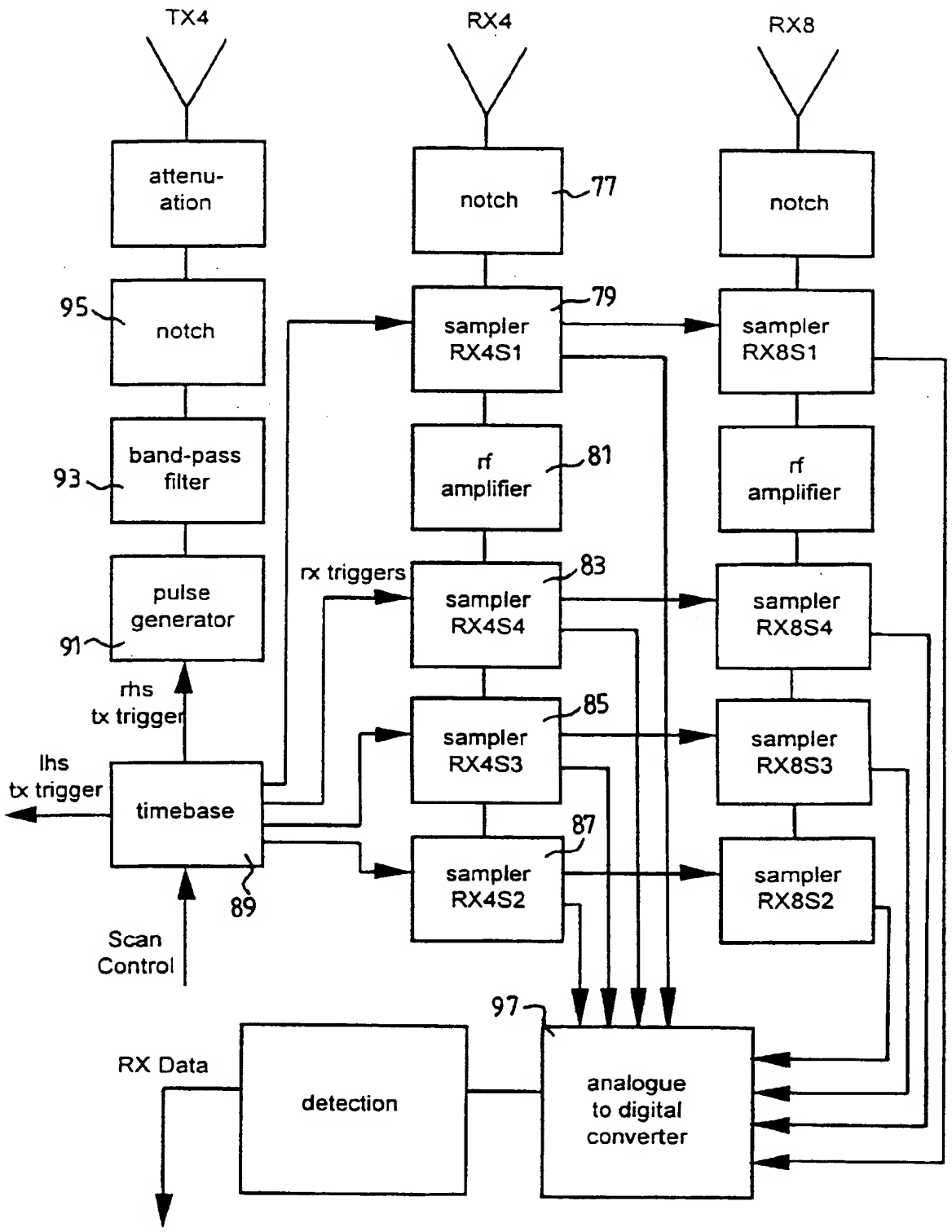

FIG.9

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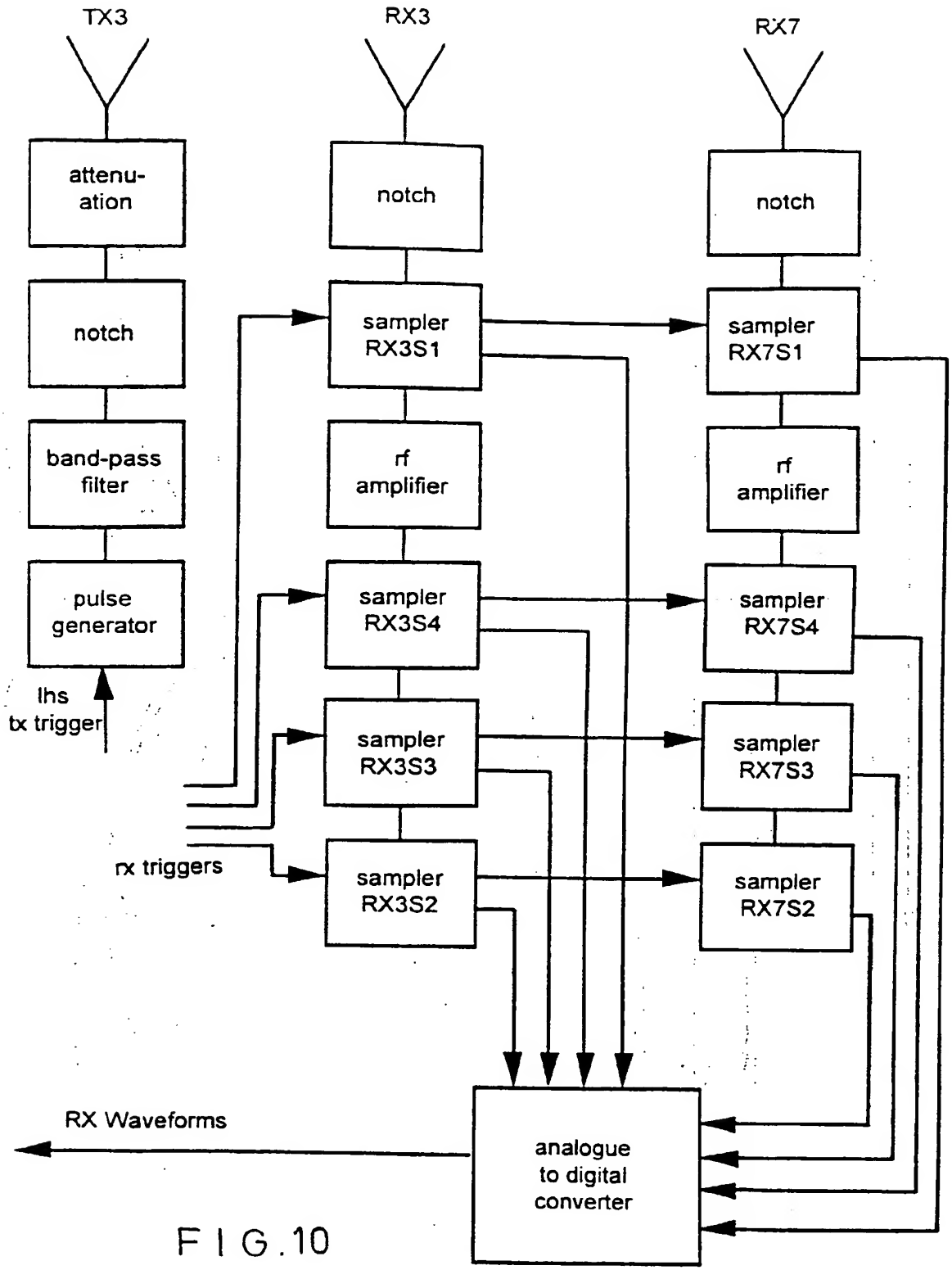

FIG.10

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(71) Applicants:
- **FORD MOTOR COMPANY LIMITED**
  Brentwood, Essex CM13 3BW (GB)
  Designated Contracting States:
  GB
- **FORD-WERKE AKTIENGESELLSCHAFT**
  50735 Köln (DE)
  Designated Contracting States:
  DE
- **FORD FRANCE S. A.**
  92506 Rueil-Malmaison Cédex (FR)
  Designated Contracting States:
  FR

(72) Inventors:
- **Smith, Graeme Peter**
  Bishops Stortford, Herts, CM23 4BW (GB)
- **Clouston, Eric Nicol**
  Chesterton, Cambirdge, CB4 1NW (GB)

(74) Representative: **Messulam, Alec Moses et al**
A. Messulam & Co.
24 Broadway
Leigh-on-Sea Essex SS9 1BN (GB)

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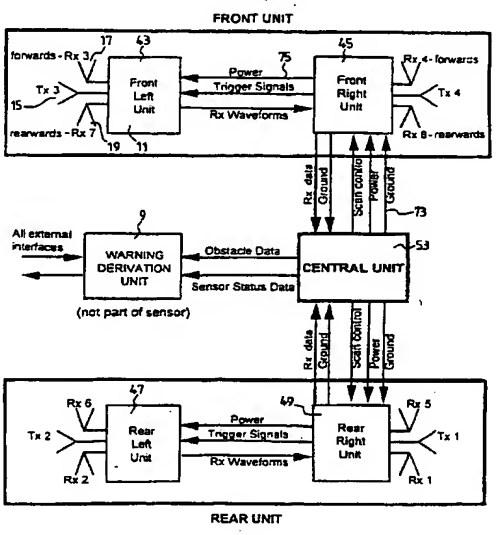

FIG.2

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 5779

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 3 745 572 A (SATO K ET AL) 10 July 1973 (1973-07-10) * abstract; figure 3 * * column 4, line 4 - line 14 * * column 5, line 53 - line 58 *	1	G01S13/93
A	EP 0 740 166 A (TRW INC) 30 October 1996 (1996-10-30) * abstract; figures 6,7 * * column 2, line 47 - line 57 * * column 3, line 24 - line 32 * * column 9, line 14 - line 39 *	1	
A	US 4 528 563 A (TAKEUCHI MIKIO) 9 July 1985 (1985-07-09) * abstract; figures 2,5 * * column 3, line 11 - line 27 * * column 5, line 18 - line 34 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H01Q G01S

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 August 1999	Niemeijer, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 5779

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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